



# Air Force Research Laboratory



## AFOSR Overview

5 March 2012

**Dr. Thomas Russell, SES**  
**Director**  
**AFOSR**

**Air Force Research Laboratory**

***Integrity ★ Service ★ Excellence***



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# AFOSR Mission



*Discover, shape, and champion basic science that profoundly impacts the future Air Force*

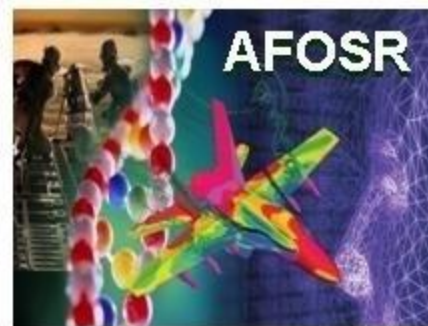
- ID Breakthrough Research Opportunities – Here & Abroad
- Foster Revolutionary Basic Research for Air Force Needs
- Transition Technologies to DoD and Industry

TODAY'S BREAKTHROUGH SCIENCE FOR TOMORROW'S AIR FORCE



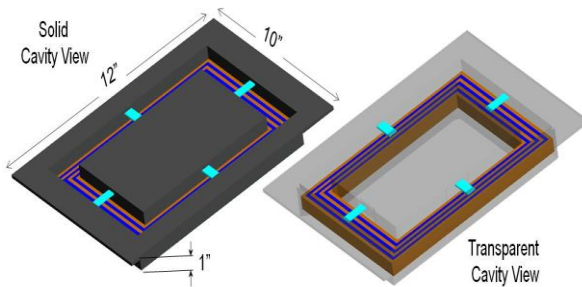


# AFRL Technical Directorates





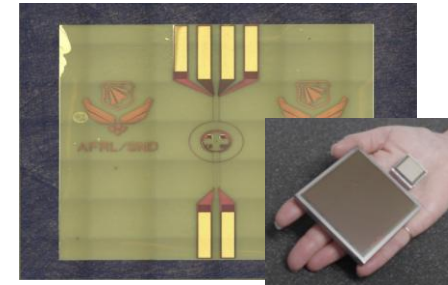
# AFOSR Supports AFRL Core Technical Competencies (CTC)



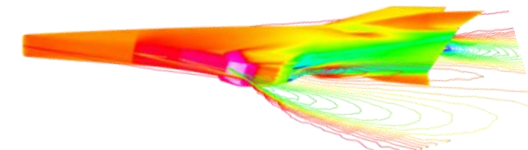
**RH – Discover & quantify size, shape, motion & molecular signatures indicative of threat**



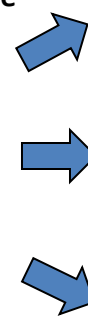
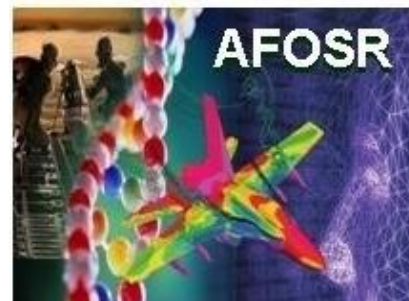
**RX - Develop new alloy and tailor micro-structure for turbine blade**



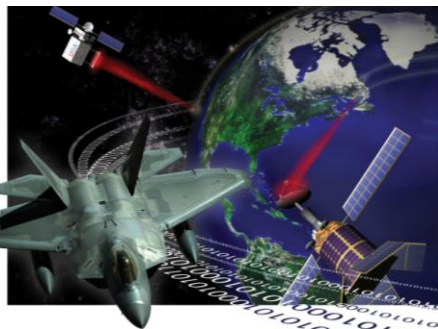
**RV – Develop electro-optical sensors & inertial navigation on chip**



**RB – Research in high speed-hypersonic flight**



**RY – Develop new radio frequency and optical metamaterial device and components**



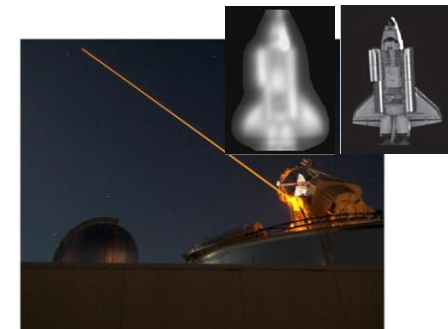
**RI – Develop robust cyber command and control system**



**RZ – Development of scramjet propulsion**



**RW - Developing new fuse and sensors technologies**

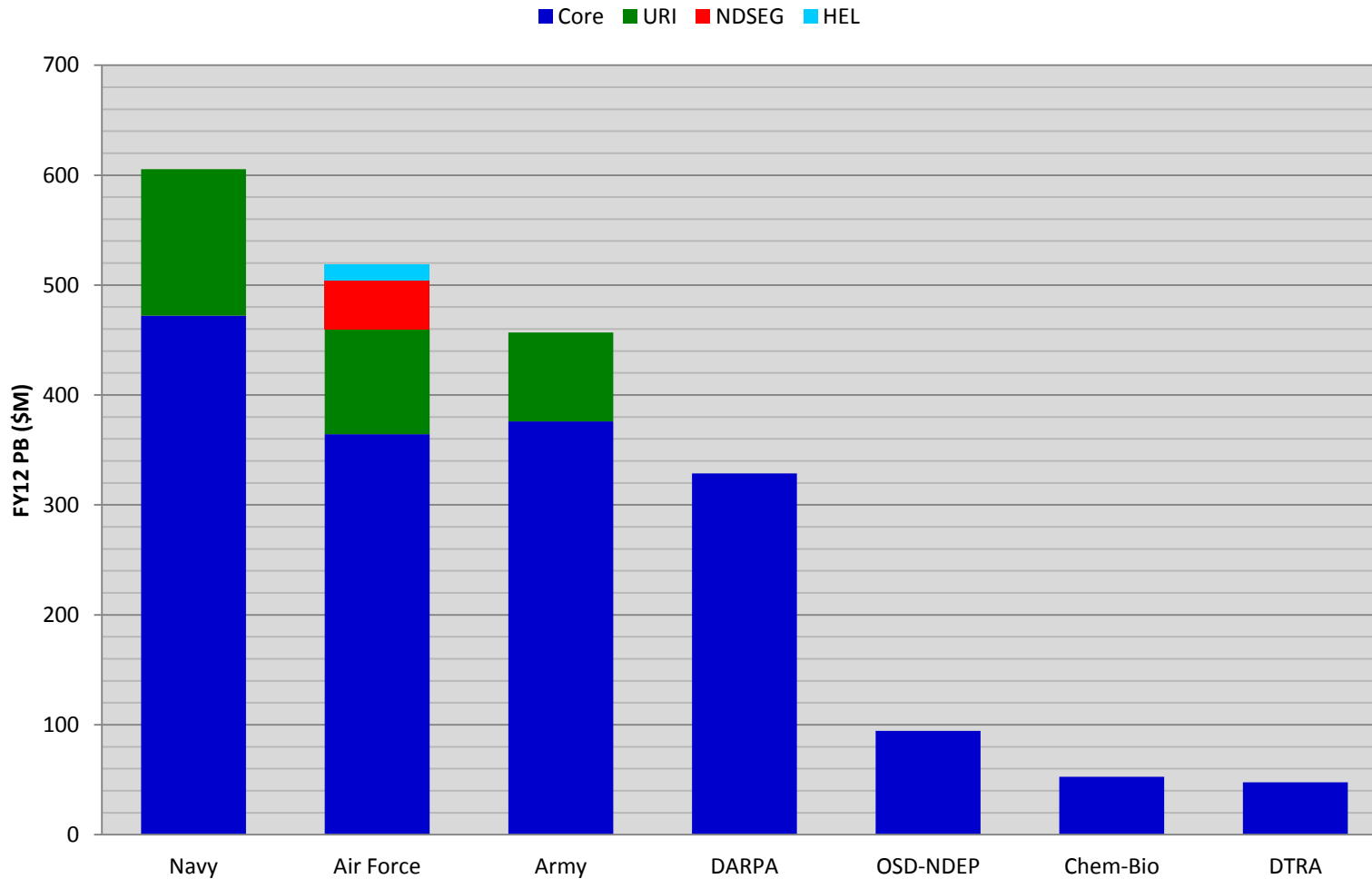


**RD - Higher-quality image restorations. Enhanced using adaptive-optics research**





# DoD Basic Research Enterprise



DoD Total FY12 Basic Research Budget = \$2.12B



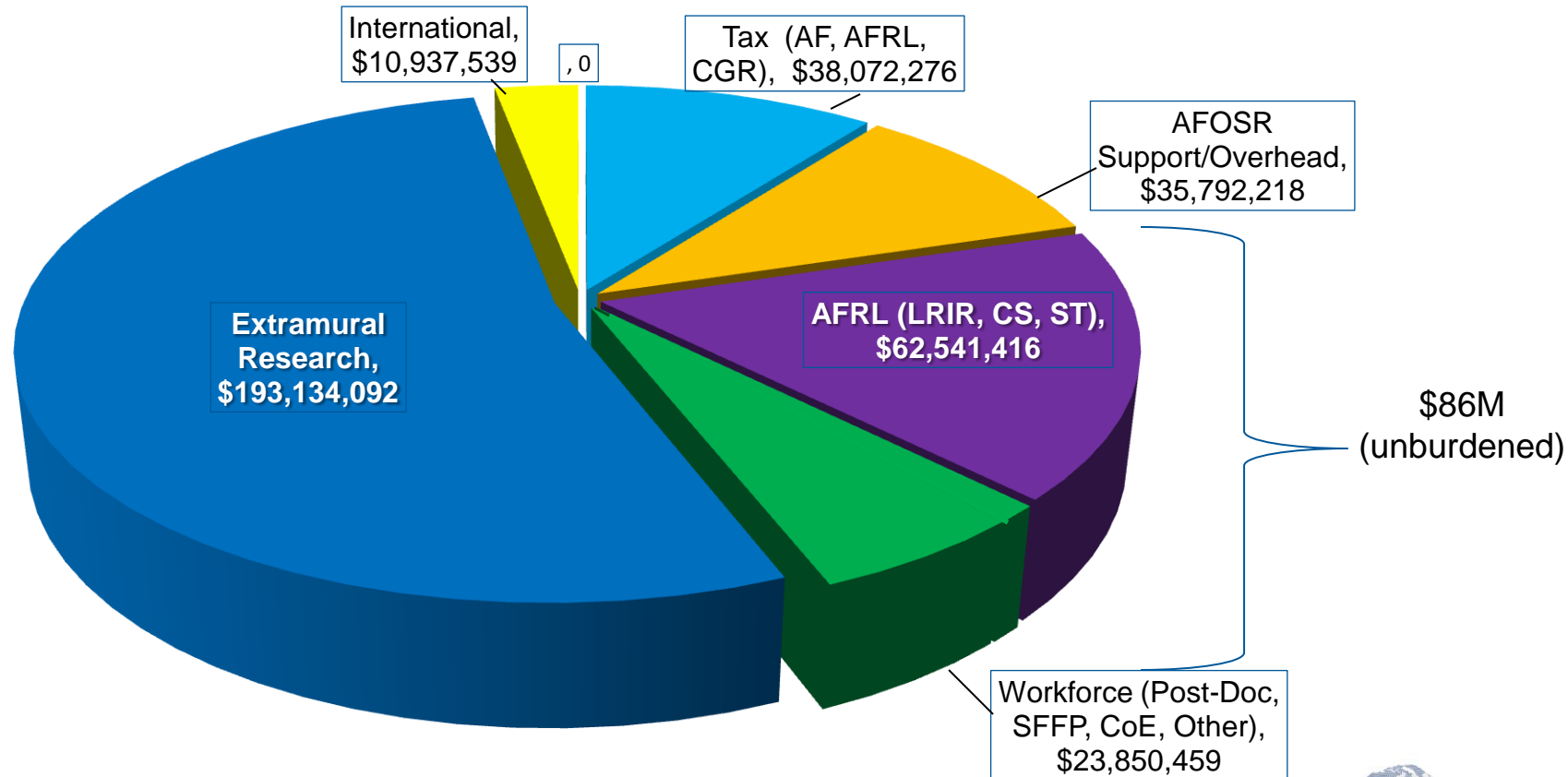




# AFOSR FY12 Budget Plan



Program Element	FY 2011	FY 2012	FY 2013*	FY 2014*
61102F (Core)	348,910	364,328	361,787	374,267
61103F (URI)	135,601	140,273	141,153	138,747





# Shaping the Research Portfolio



Goals for AFOSR to strengthen the Air Force basic research program as defined in AF S&T Strategic Plan:

- **Provide scientific leadership for the AF basic research enterprise**
- **Attract the Nation's/World's best S&Es to contribute to and lead AF/DoD research**
- **Ensure the coherence and balance of the AF basic research portfolio**
- **Foster connections between AFRL researchers and the National/International basic research community**
- **Maximize the discovery potential of the defense research business environment**

*Focus on the Future AF with the ultimate goal to make  
Today's AF and Tomorrow's AF Obsolete!*





# Shaping the Research Portfolio



Though a principal source of new scientific opportunities is bottom up from the scientific community through AFOSR PMs, we also consider the assessment of opportunities by AF and OSD

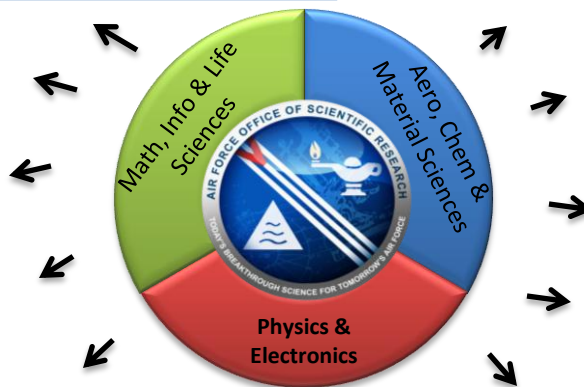
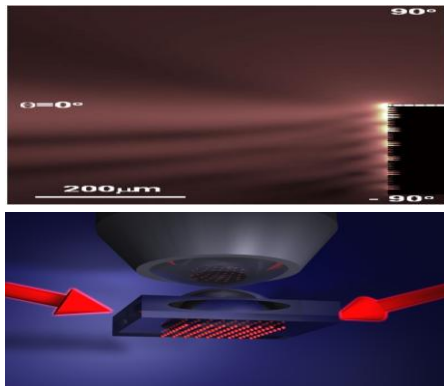
## AF/ST “Technology Horizons”

Inherently Intrusion-Resistant Cyber Networks

Trusted Highly-Autonomous Decision-Making Systems

Hyper-Precision Air Delivery in Difficult Environments

Fractionated, Composable, Survivable Remote-Piloted Systems



Metamaterials and Plasmonics

Quantum Information Science

Cognitive Neuroscience

Nanoscience and Nanoengineering

Synthetic Biology

Computational Models of Human Behavior

## ASD(R&E) “Six Disruptive Basic Research Areas”





# Trends in AFOSR Emphasis



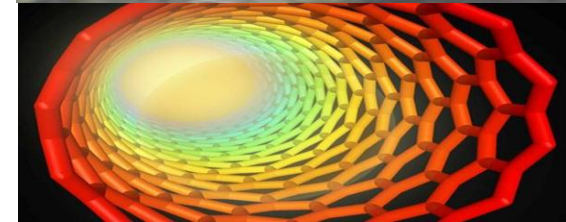
- Advanced Mathematics
- Hypersonics (Turbulence Control)
- Complex, Multi-Functional Materials
- High-Temperature Superconductivity
- Info Assurance and Network Sciences
- Micro Air Vehicles (Autonomy, Adaptive Aero)
- Interfacial Sciences (Thermal, Tribology)
- Counter-Directed Energy Weapons
- Robust Decision-Making, Info Fusion
- Socio-Cultural Modeling, Minerva
- Quantum Information Sciences
- Space Situational Awareness
- fs-Laser Material Interactions
- Artificial Intelligence

*RED = PBD709 (OSD Interest)*

*BLUE = AF Tech Horizons*

*Grand Challenges*

*GREEN = Both*





# Invest in AF “Technology Horizons” Research Areas



- **PBD 709 Topic Enhancements**

- Information Assurance
- Interacting Complex Networks
- Artificial Intelligence
- Socio-Cultural Modeling

- **Materials and Processes Far from Equilibrium**

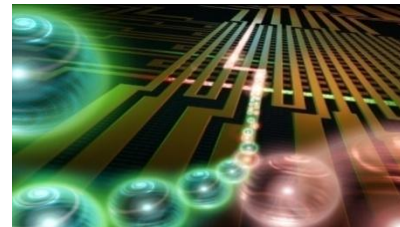
- Physics and Chemistry of Surfaces in Highly Stressed Environments
- Small Molecule Activation
- Extreme Optics

- **Transformational Computing**

- Neural Computing
- Bio-Inspired Distributed Control Sys.
- Beyond Moore’s Law Electronics
- Multiscale Modeling

## Tech Horizons Grand Challenges

1. Inherently Intrusion-Resistant Cyber Networks
2. Trusted Highly-Autonomous Decision-Making Systems
3. Fractionated, Composable, Survivable Remote-Piloted Systems
4. Hyper-Precision Air Delivery in Difficult Environments





# Basic Research Initiative Program



- The Basic Research Initiative program provides a mechanism to fund new Projects aligned to identified emphasis areas.
- Funded by a 10% assessment on the prior year budgets of all research portfolios (PE61102F funding)
- Program managers nominate research topics that are reviewed for scientific merit and alignment to the AFOSR technical strategy
- New research areas identified via a broad agency announcement

## FY12 BRI Topics

- Ultra-cold and strongly coupled plasmas
- Micro-resonator-based optical frequency combs
- Origami design for the integration of self-assembling systems
- Active, functional nanoscale oxides
- Reliance optimization for autonomous systems
- Bio-nanocombinatorics
- Design under uncertainty of complex engineering systems





# New BRI Topics for Potential Collaborations



- 1. Layered structured 2D-materials for extreme environment**
- 2. Autonomic material systems utilizing biomolecular transduction**
- 3. Transformational computing via co-design of high-performance algorithms and hardware**
- 4. High peak power, ultrashort laser ablation of solids**
- 5. Sustainable alloy design: Rare earth materials challenge**
- 6. Catalytic reactions in endothermic cooling systems**
- 7. Foundations of energy transfer in multi-physics flow phenomena**
- 8. Cyber trust and suspicion**
- 9. Ultra-scale and fault-resilient algorithms: Mathematical algorithms for ultra-parallel computing**



# Future AFOSR Plans



- Increase emphasis:
  - ASD (R&E) disruptive basic research areas
  - Cyber/Software
  - Human performance enhancement (physiology related topics)
  - Structural materials & mechanics
- Decrease emphasis:
  - Bioenergy/Biofuels
  - Thermosetting polymers/surface adherents
  - Adaptive, self-healing materials
  - Complementary metal–oxide–semiconductor (CMOS)

# ***AFOSR Ten Focus Areas***

***(FY12 - \$364.3M)***

## **Aerospace, Chemical & Material Sciences**

- Aero-Structure Interactions & Control
- Energy, Power & Propulsion
- Complex Materials & Structures

## **Physics & Electronics**

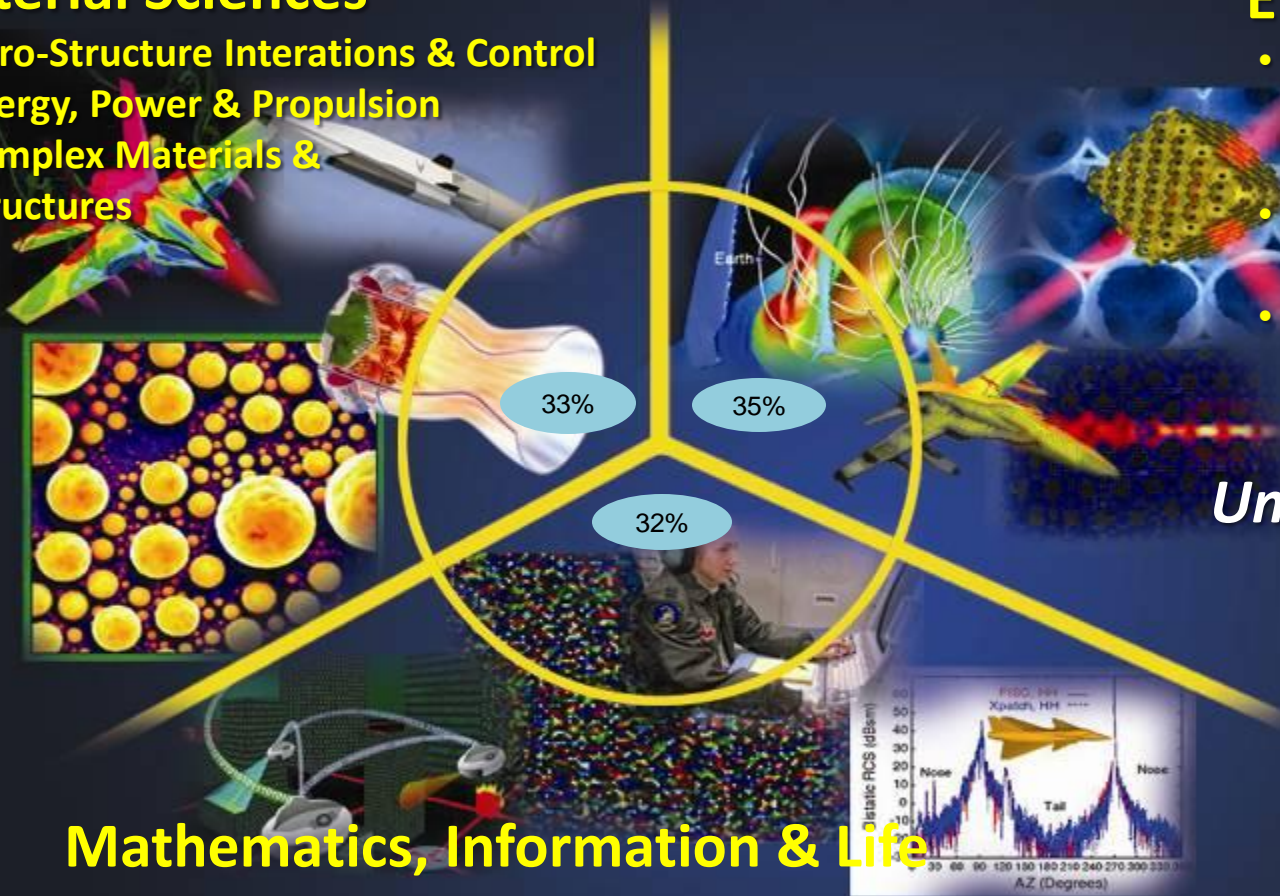
- Complex Electronics & Fundamental Quantum Processes
- Plasma Physics & High Energy Density
- Optics, EM, Comm, Signals Processing

## ***University Research Initiatives***

***(FY11 - \$140.2M)***

## **Mathematics, Information & Life Sciences**

- Info & Complex Networks
- Decision Making
- Dynamical Sys, Optimization & Control
- Natural Materials & Systems





# Mathematics, Information & Life Sciences

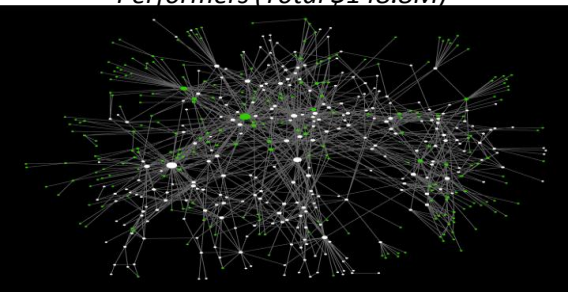


Industry, \$5.8

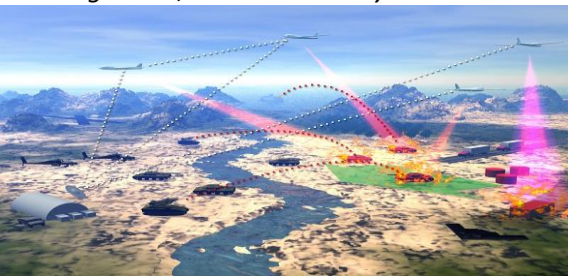
AFRL,  
\$14.9

Academia, \$128.1

Performers (Total \$148.8M)



*Math guarantees of performance for policy, protocol, and security using new coding, management, and online analysis methods.*



*Enabling distributed control of flexibly autonomous agents for performing single or multiple tasks and missions.*

## Information and Complex Networks:

- Science of cyber security
- Mathematics of complex networks
- Software/algorithms for advance computational architectures

## Decision-Making:

- Robust computational intelligence
- Mathematical basis for neurobiological processes
- Trust, autonomy, and the human-machine interface
- Effect of culture on influence

## Dynamical Systems, Optimization and Control:

- Multiagent, networked control
- Uncertain, information-rich, dynamic environments
- Contested environments
- Dynamic, data-driven control

## Natural Materials and Systems:

- Bio-inspired materials
- Bio-derived materials including energy
- Bio-sensing
- Extremophiles





# Math, Information & Life Sciences

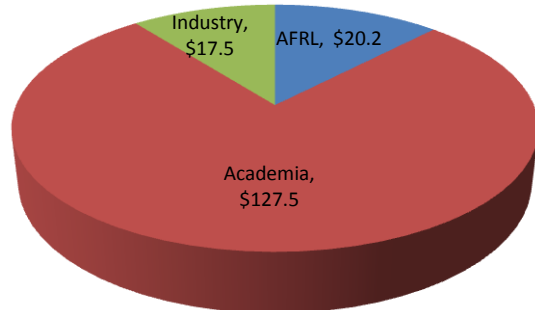
## March 5 - 6



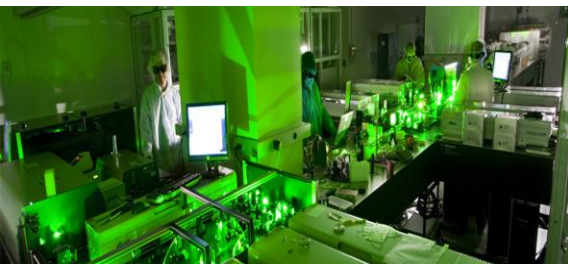
- **Information and Complex Networks (March 5: 1025-1515)**
  - Complex Networks/Foundations of Information Systems - **Dr. Robert Bonneau**
  - Information Operations and Security - **Dr. Robert Herklotz**
  - Software and Systems - **Dr. Robert Bonneau**
  - Science of Information, Computation and Fusion - **Dr. Tristan Nguyen**
  - Dynamic Data Driven Applications Systems - **Dr. Frederica Darema**
- **Decision Making (March 5: 1535-1700)**
  - Cognitive Modeling and Robust Decision Making - **Dr. Jay Myung**
  - Trust and Influence - **Dr. Joseph Lyons**
- **Dynamical, Control, Optimization and Computational Math (March 6: 0850-1115)**
  - Dynamics and Control - **Dr. Fariba Fahroo**
  - Optimization and Discrete Mathematics - **Dr. Don Hearn**
  - Computational Mathematics - **Dr. Fariba Fahroo**
- **Natural Materials and Systems (March 6: 1300-1525)**
  - Sensory Information Systems - **Dr. Willard Larkin**
  - Bioenergy - **Dr. Patrick Bradshaw**
  - Natural Materials, Systems and Extremophiles - **Dr. Hugh DeLong**



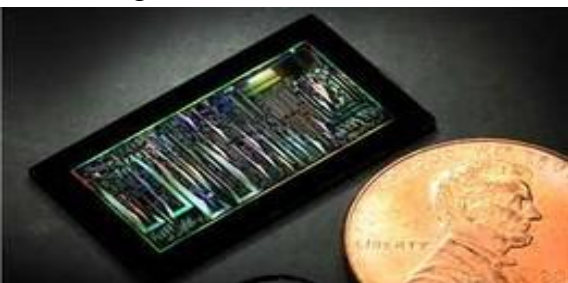
# Physics & Electronics



*Performers (Total \$165.2M)*



*Diocles laser, which produces the most intense light on earth.*



*Combining low-cost silicon chips with tiny lasers to send bits of data using light rather than pulses of electricity.*

## Complex Electronics and Fundamental Quantum Processes:

- Ultracold Atoms & Molecules
- Metamaterials & Graphene
- Dielectric and Magnetic Materials
- High Temperature Superconductors
- Novel Sensing Devices and Architectures
- Non-linear Optical Materials, Optoelectronics, and Nanophotonics

## Plasmas & High Energy Density Nonequilibrium Processes:

- Space weather
- High power microwave devices
- Cold, dense, degenerate plasmas
- RF propagation and RF-plasma interaction
- Plasma discharges & non-equilibrium chemistry
- Plasma control of boundary layers in turbulent flow

## Optics, Electromagnetics, Communication, & Signal Processing:

- Information fusion
- Lasers and non-linear optics
- RF and EO signal processing
- Novel RF devices and communication architectures



# Physics & Electronics

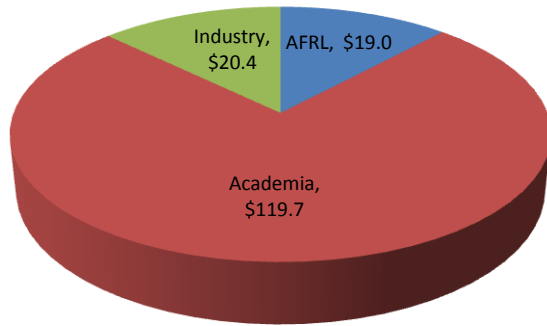
## March 7-8



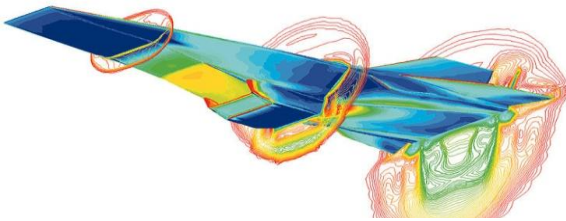
- **Plasma Physics and High Energy Non-equilibrium Processes (March 7: 0830-0955)**
  - Plasma and Electro-Energetic Physics - **Dr. John Luginsland**
  - Space Sciences - **Dr. Cassandra Fesen**
- **Optics, Electromagnetics, Communication, & Signal Processing (March 7: 1015-1220)**
  - Remote Sensing and Imaging Physics - **Dr. Kent Miller**
  - Sensing Surveillance & Navigation - **Dr. Jon Sjogren**
  - Electromagnetics - **Dr. Arje Nachman**
- **Complex Electronics and Fundamental Quantum Processes (March 7: 1350-1735)**
  - Lasers and Optics - **Dr. Howard Schlossberg**
  - Atomic and Molecular Physics - **Dr. Tatjana Curcic**
  - Adaptive Combinatorial Multimodal Sensing Physics and Methods - **Dr. Kitt Reinhardt**
  - Optoelectronic Information Processing - **Dr. Gernot Pomrenke**
  - Quantum Electronic Solids - **Dr. Harold Weinstock**
- **Complex Electronics and Fundamental Quantum Processes (March 8: 0830-0955)**
  - GHz-THz Electronics - **Dr. Jim Hwang**
  - Ultrashort Pulse (USP) Laser-Matter Interactions - **Dr. Riq Parra**



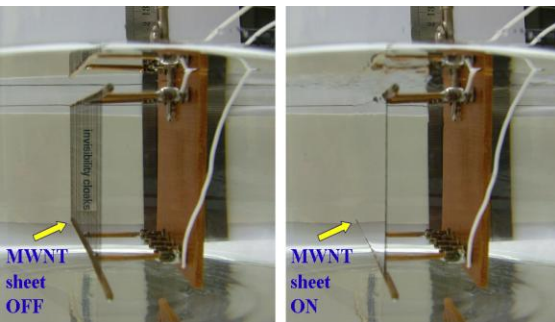
# Aerospace, Chemical, and Material Sciences



Performers (Total \$159.1M)



Model-free simulations of >Mach 3 shock turbulent boundary layer interactions



Application of a nanotube sheet as a mirage based concealment cloak is demonstrated in water.

## Aero-Structure Interactions and Control:

- Turbulence and laminar-turbulent transition
- Unsteady aerodynamics and flow control
- Aero-elasticity and structural dynamics
- Integrated Modeling

## Energy, Power and Propulsion:

- Novel energetic materials
- Combustion and catalysis chemistry
- Thermal science
- Novel means of producing, collecting and storing energy
- System-level analysis and modeling

## Complex Materials and Structures:

- Novel lightweight materials
- Materials with tunable properties
- Reconfigurable structures
- Multifunctional materials and structures





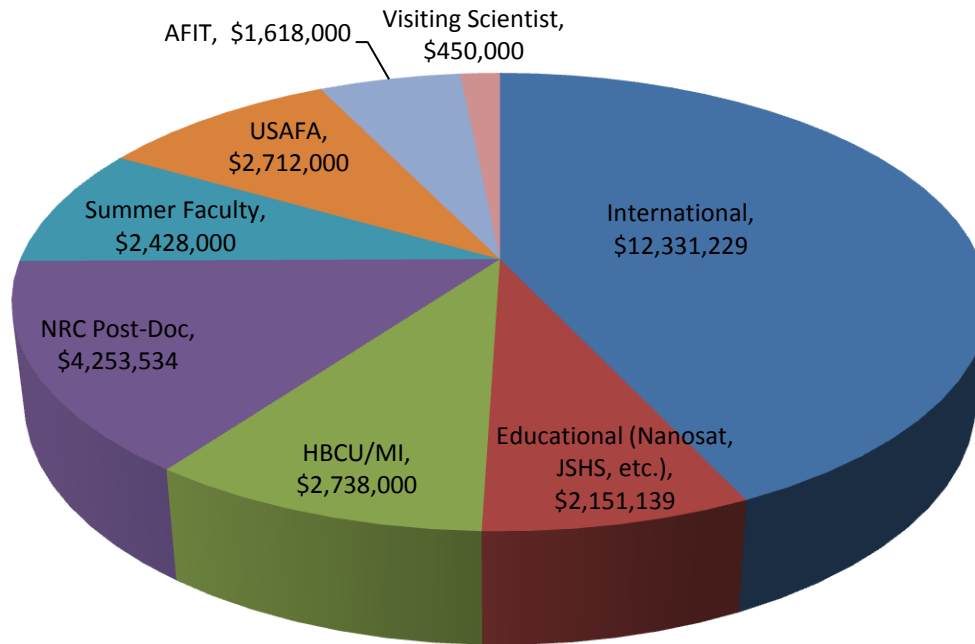
# Aerospace, Chemical, and Material Sciences: March 8-9



- **Aero-Structure Interactions and Control (March 8: 1015-1220)**
  - Flow Interactions and Control - **Dr. Douglas Smith**
  - Aerospace Materials for Extreme Environments - **Dr. Ali Sayir**
  - Aerothermodynamics and Turbulence- **Dr. John Schmisser**
- **Energy, Power, and Propulsion (March 8: 1350-1700)**
  - Molecular Dynamics and Theoretical Chemistry - **Dr. Jeffrey Owrutsky**
  - Energy Conversion and Combustion Sciences - **Dr. Chiping Li**
  - Space Propulsion and Power - **Dr. Mitat Birkan**
  - Thermal Sciences - **Dr. Joan Fuller**
- **Complex Materials and Structures (March 9: 0830-1135)**
  - Mechanics of Multifunctional Materials & Microsystems - **Dr. Byung-Lip (Les) Lee**
  - Multi-Scale Structural Mechanics and Prognosis - **Dr. David Stargel**
  - Low Density Materials - **Dr. Joycelyn Harrison**
  - Organic Materials Chemistry - **Dr. Charles Lee**



# Education and Outreach



FY11 Total Core Funding: \$28.6M



ASSURE site  
at Fort  
Johnson, NY



USA Science &  
Engineering  
Festival, DC  
2010

## Educational Projects in 61103F (URI)

- **National Defense Science and Engineering Graduate Fellowship (NDSEG) Program (\$36M):** Supporting 590 PhD-track graduate students in DoD relevant fields
- **Awards to Stimulate and Support Undergraduate Research Experience (ASSURE) (\$4.5M):** Provides 550 undergraduates with research opportunities in S&E fields of DoD interest during summer months

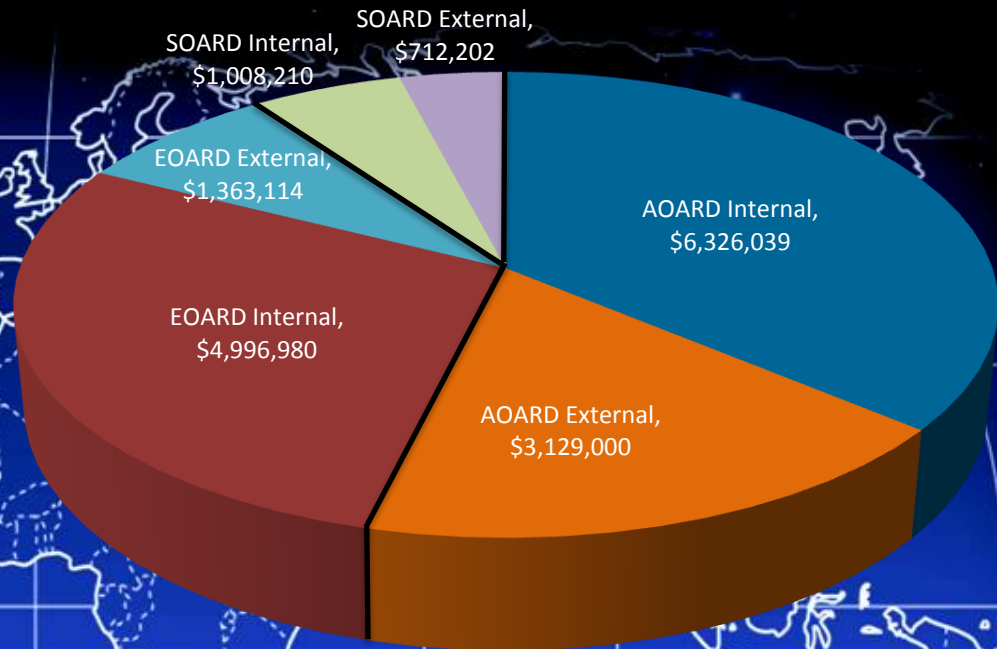


# AFOSR International Enterprise



Total Funding (All Sources): \$17.5M

- **Building international goodwill**
- **Strengthening partnerships**
- **Avoiding technological surprise**
- **Accelerating S&T achievements and transitions to the U.S.**



## AOARD

ASIAN OFFICE OF AEROSPACE RESEARCH  
AND DEVELOPMENT

Tokyo

## EOARD

EUROPEAN OFFICE OF AEROSPACE  
RESEARCH AND DEVELOPMENT

London

## SOARD

SOUTHERN OFFICE OF AEROSPACE  
RESEARCH AND DEVELOPMENT

Santiago

***The Sun Never Sets on AFOSR***



# International Research Achievements



- **Perching of Micro Air Vehicles: R. Radespiel, Technische Universität Braunschweig, (EOARD)**

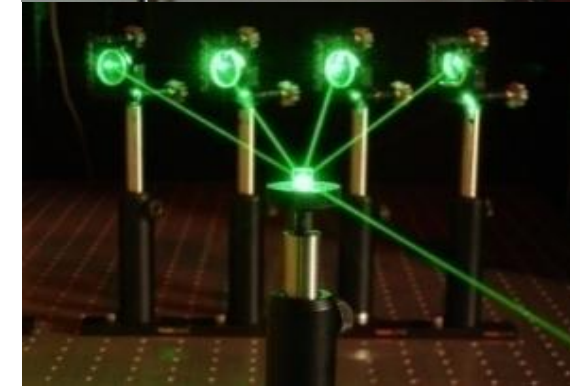
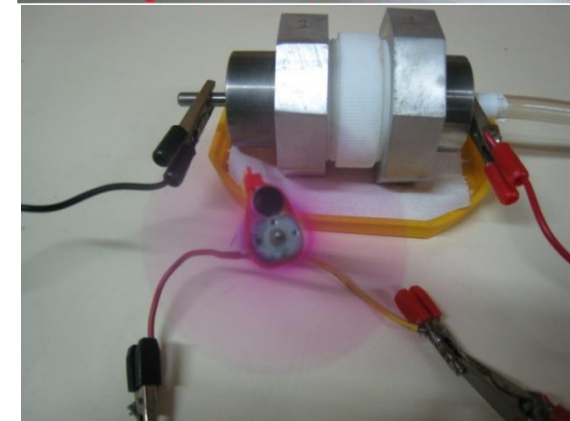
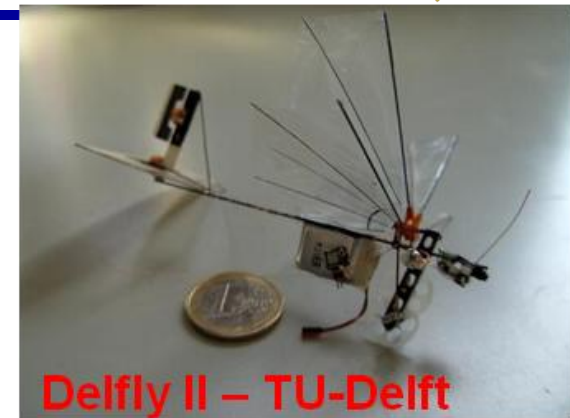
Identified & characterized unsteady flow phenomena on flat plate wings during perching motion by force measurement and particle image velocimetry.

- **Lithium - Air Battery: M. Nookala, Indian Institute of Science, India, (AOARD)**

Li-air batteries use a catalytic air cathode that supplies oxygen, an electrolyte and a lithium anode. Potential to have a capacity for energy storage that is 5 to 10 times greater than that of Li-ion batteries.

- **Photorefractive Polymers: Research Center in Advanced Chemistry (CIQA), Mexico, (SOARD)**

Developed the world's smallest ferroelectric nanoparticles – small as 9 nm. High resolution proved hypothesis that surface stress was key to success.





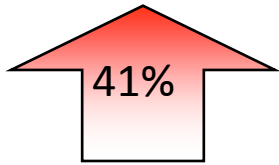
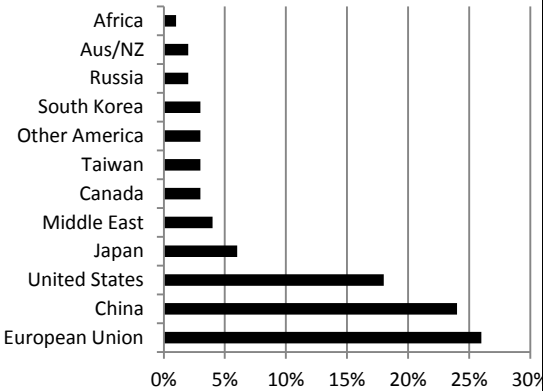


# World R&D Publications (2000 to 2010):

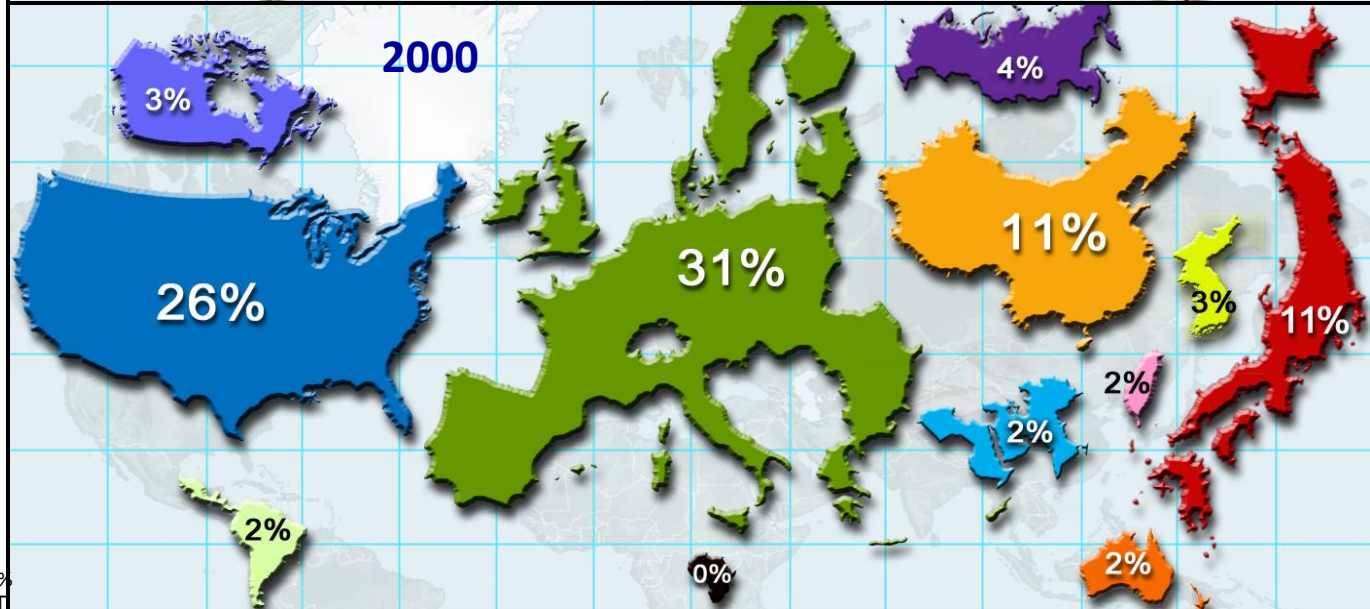
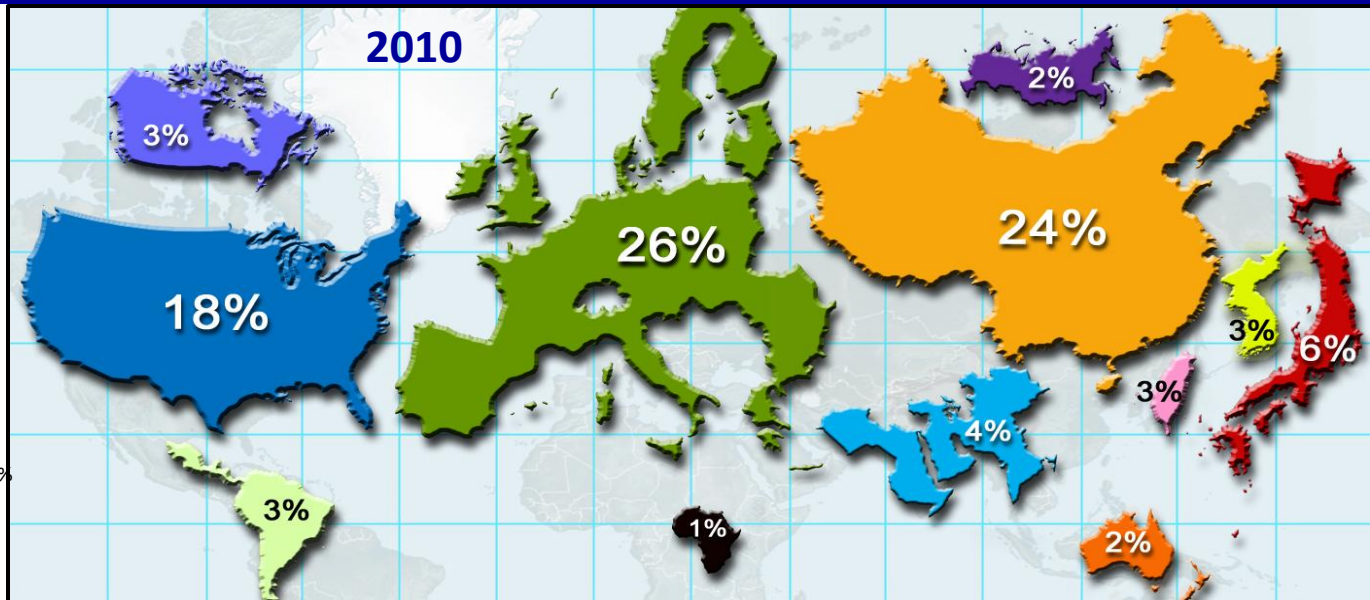
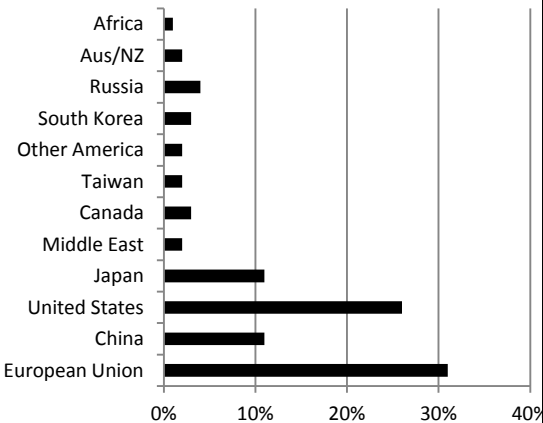
US share of global R&D steadily decreasing



**2010** 898,416 Articles



**2000** 636,358 Articles





# Summary



*AFOSR continues to discover, shape, and champion basic science that profoundly impacts the future Air Force*

- **Supporting world-class basic research**
- **Educating tomorrow's scientific leaders**
- **Providing meaningful transitions and for future**
- **Enhance mutual understanding of AFOSR and other organizations missions, roles, programs, priorities**
- **Ensure current investments are fully coordinated and opportunities for leveraging are exploited**

"Innovation also demands basic research. Today, the discoveries taking place in our federally-financed labs and universities could lead to ... New lightweight vests for cops and soldiers that can stop any bullet. Don't gut these investments in our budget. Support the same kind of research and innovation that led to the computer chip and the Internet."

- President Obama, State of Union Speech, 24 January 2012



AIR FORCE OFFICE OF SCIENTIFIC RESEARCH 1951 - 2011 AFRL

# Happy 60<sup>th</sup> Birthday

# AFOSR

## 1951 - 2011

6 March 2012



**Dr. Chad Mirkin**

Director of the International Institute for Nanotechnology  
Northwestern University

Title: Nanotechnology: - Moving Beyond Small Thinking





# Social Media

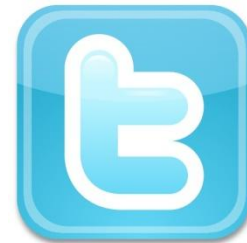


AIR FORCE OFFICE OF SCIENTIFIC RESEARCH 1951 - 2011 AFRL

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